Space Weather Technical Forecast

Issued on Monday, 12 September 2022 at 01:12 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Increased Chance of M-class flares. Ongoing Active electron fluence ahead of possible Minor geomagnetic activity midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity saw a sharp upturn through the UTC day of Sunday 11 September relative to much of the week that preceded it, with this largely tied to the fortunes of a developing sunspot region in the northern central disc. X-ray flares at GOES16 and 17 rose to frequent mid-level C-class from 09UTC, having previously showed a relatively flat trend near the boundary of B and C-class flux. The peak flare of the period was a C6.1 at 11/2228UTC, emitted from AR3098 but with some contribution from a consecutive event on the southeastern limb. This main sunspot was AR3098, which finished the 24 hours as a Dac/Beta-Gamma, with spreading and areal growth, with its intermediate spots in particular seeing the development of numerous penumbrae.

There were seven numbered sunspot regions on the disc in total, with the above by far the largest and most dynamic, but supported in activity to a minor extent by AR3100 in the southeast, which grew slightly but retained its Cai/Beta classification, and AR3101 in the northwest, which saw areal growth proliferation and spreading (to a lesser degree than AR3098), finishing as a Dai/Beta. All the other constituent regions on the disc were smaller, simpler and either stable or in decay.

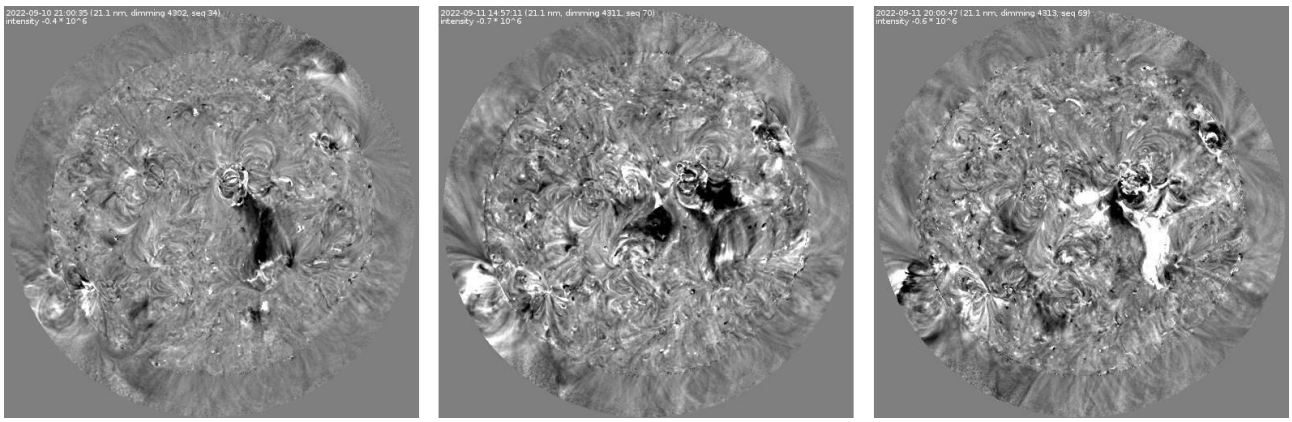

Figure 0: Time-integrated AIA 211 imagery, showing up to three centre-disc dimmings in the past 30 hours related to reconfiguring or disappearing filaments. At the time of writing, none has resulted in obvious ejecta on coronagraph imagery, however this is being monitored. Image processing courtesy of SIDC ROB.

Coronal Mass Ejection (CME) activity in the period also increased, with Lasco C2 and C3 imagery during the early hours UTC characterised by a high solar latitude prominence eruption, directed both well above the ecliptic and rearward from the Sun; while a second eastern limb eruption saw out the morning. During the afternoon, a chain of events saw one of the near 20 degree-spanning

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centre-disc filaments disappear (as evidenced in El Teide H-Alpha around 11/1300UTC). This has yet to manifest on coronagraph imagery but is being monitored.

No new Earth-directed CMEs were in evidence at the time of writing.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, was at slightly elevated levels, with the decline seen earlier in the weekend halting, perhaps suggesting that there was a transition from the long-lasting positive polarity CH20 into the smaller and lower magnitude CH24/+.

The solar wind speed was erratic but with a roughly level average about 450km/s. The solar wind density was near its long-term background in single figures ppcc, while the IMF was stable below 7nT throughout. The north-south component was variable between +/-5nT, with a slight bias from co-aligned early in the 24 hours to anti-aligned later on. The phi angle was mainly positive (away from the Sun).

The net result of the above solar wind measures was provisionally mainly Quiet to Unsettled, but with a peak Kp of 4- seen in the 15-18UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16, remained slightly above its characteristic background trace, plateauing around 1pfu, i.e. significantly below the requisite 10pfu for S1.

The high energy electron flux (greater than 2 MeV) ranged from Moderate to High, peaking at a higher diurnal peak than of late at 2.16e4 pfu at 11/1605UTC. The corresponding 24-hour electron fluence remained above Active (1e8 integrated pfu) with a falling then rising trend, resulting in a 12/0001UTC observed value of 3.29e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be higher than of late: Low but with a daily Chance of Moderate, with this a result of the growth of AR3098 in particular, but also potentially accentuated by AR3101 and AR3100, as well as the arrival of Ex-3088 over the eastern solar horizon.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast carries low confidence. Activity should become increasingly Quiet through the first days of the UTC week, with CH24/+ soon fading, however interaction between any remnant of CH22 and a possible partial halo CME of uncertain origin from 09 September may lead to a Slight Chance of G1 later on Wednesday 14 into Thursday 15 September.

Despite other recent centre-disc disappearing filament CME candidates, they have not appeared in coronagraph imagery and none yet feature in the forecast.

Energetic Particles / Solar Radiation: High energy protons (greater than 10 MeV) are expected to remain below S1/Minor radiation storm levels.

The high energy (greater than 2 MeV) electron flux is currently fluctuating between High and Moderate levels, and is Likely to remain so until midweek UTC, whereupon a combination of any remnant of coronal hole 22 and perhaps the 09 September CME may act to redistribute electrons.

The corresponding 24-hour fluence is expected to see only a gradual ebb at first in the period, but is Expected to remain above Active (1e8 integrated pfu) until midweek, with a Chance of survival should geomagnetic activity not materialise.

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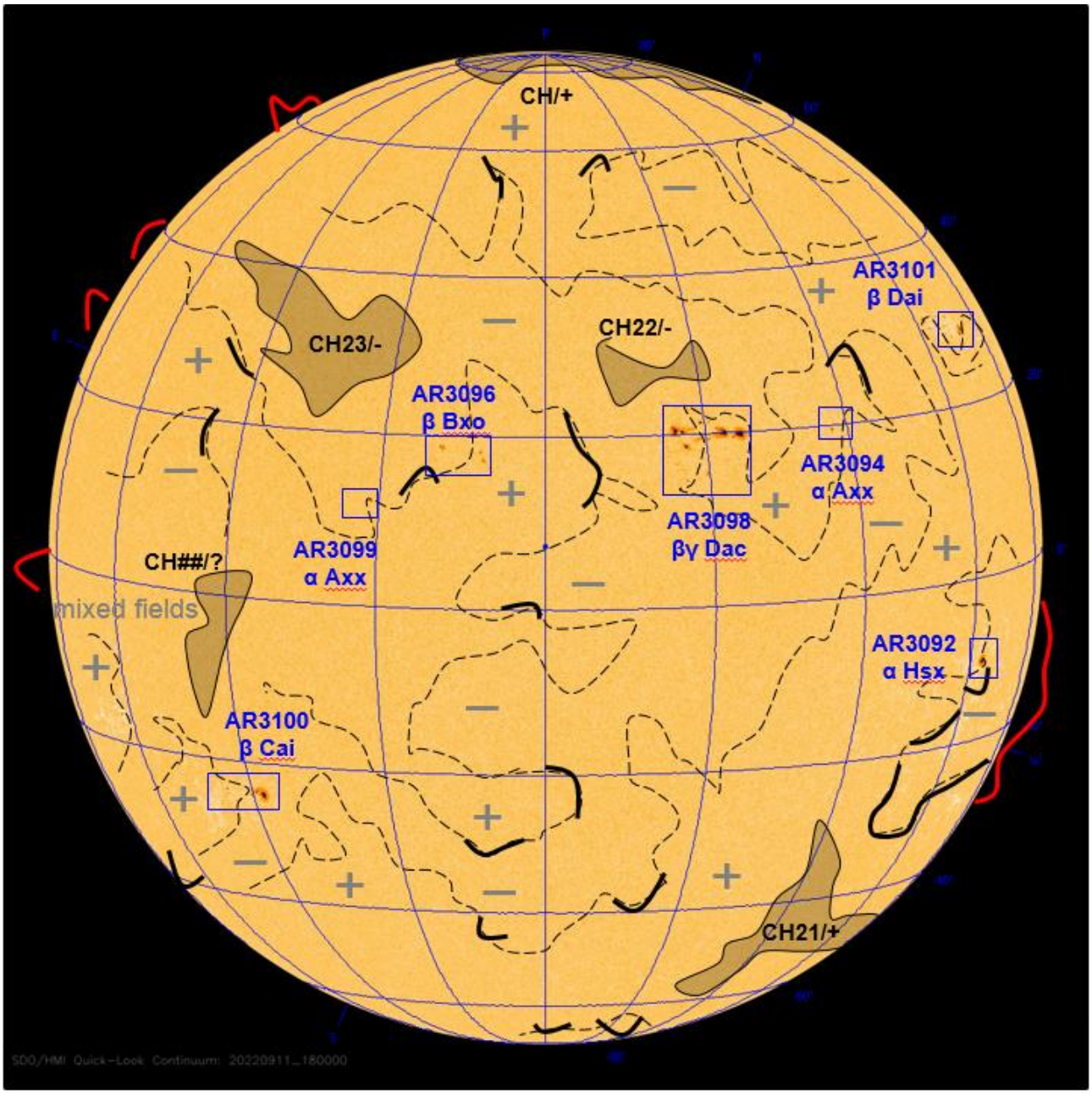
Figure 1. Solar Analysis Valid 11/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast for the coming four-day period carries relatively low confidence, especially into the second half.

The change in characteristics of the fast wind: from a decline in a positive phi regime to a level trend perhaps implies a succession in responsible features, presumably CH20 into the fainter CH24/+. This fast wind should soon ease into the new working week UTC, with a lull in activity then expected for a time.

The second half of the forecast period is especially low confidence, with the weak remnant successor to a very large coronal hole from last rotation (the now faint and fragmentary CH22/-) perhaps affecting Earth later on Wednesday 14 September. On its own, this is not likely to be particularly potent due to its polarity and tenuous appearance, however it may be bolstered by a slow and diffuse CME from 09 September. The source of this CME is not immediately apparent, but may be filament-related as there is a gap in H-alpha capability around UTC dawns at present as Udaipur is in monsoon season.

In addition to the above, recent near centre-disc disappearing filaments (particularly 10/1900UTC and 11/1300UTC) add uncertainty into the mix, although neither currently show in available coronagraph imagery.

All considered, residual influence from CH24/+ should reduce through day one, Sunday 11 September. Unsettled geomagnetic activity should fall to become predominantly Quiet through Monday 12 September, continuing Tuesday. There is then an increasing Slight Chance of Minor Storm G1 later in the four days, peaking late Wednesday 14 September into Thursday 15 September.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	1	1	10	20
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/0251	Partial	Unknown	Unknown	232km/s	Around turn of UTC day 14 into 15 September	Low confidence, source not identfied.

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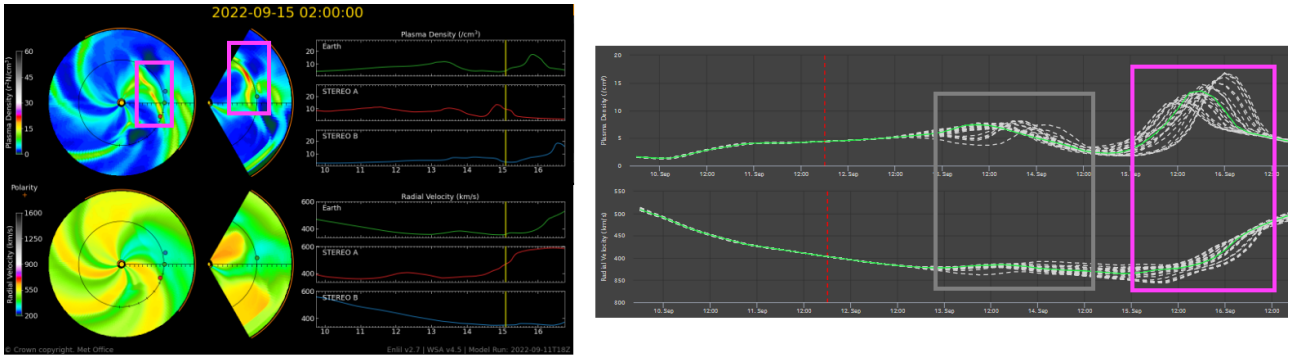
Figure 2: Latest MOSWOC Enlil run and 24-member ensemble, showing possible minor geoeffective CME from 09 September interacting with the CIR leading CH22/- to arrive around the turn of the UTC day Wednesday 14 into Thursday 15 September (magenta). Also shown is minor skirting influence from a CME (in grey) that left the sun directed largely south of the ecliptic on 07 September. This feature will most likely miss to no effect at Earth.



Radio Blackouts - X-Ray Flares:

The trend in the risk of X-ray flares is expected to be upwards in this four-day forecast, with the Penticton 10.7cm flux rising sharply from the high 120s of sfu to peak at 152 on Sunday 11 September. GOES16 has shown a significant upturn in background X-ray flux and both the cadence and magnitude of C-class flares. This uptick has been largely tied to an increase in complexity in AR3098, which became a Dac/Beta-Gamma by the most recent 24-hour reporting period's end.

There are currently seven numbered regions on the solar disc. By far the most notable of these is now AR3098 near centre disc, and the daily chances of M-class flares have been adjusted upwards accordingly to give a daily Chance of M and Slight Chance of X. Potentially adding to this raised risk is returning Ex-3088, which is now visible as flux looping over the southeastern limb. No active regions of note leave the disc in the period, and the chances of significant flares are therefore level throughout.

X Ray Flares / **Probability**	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** / **(%)**	**Day 2 (00-24 UTC)** / **(%)**	**Day 3 (00-24 UTC)** / **(%)**	**Day 4 (00-24 UTC)** / **(%)**
Active	**R1-R2 M Class**	No	40	40	40	40
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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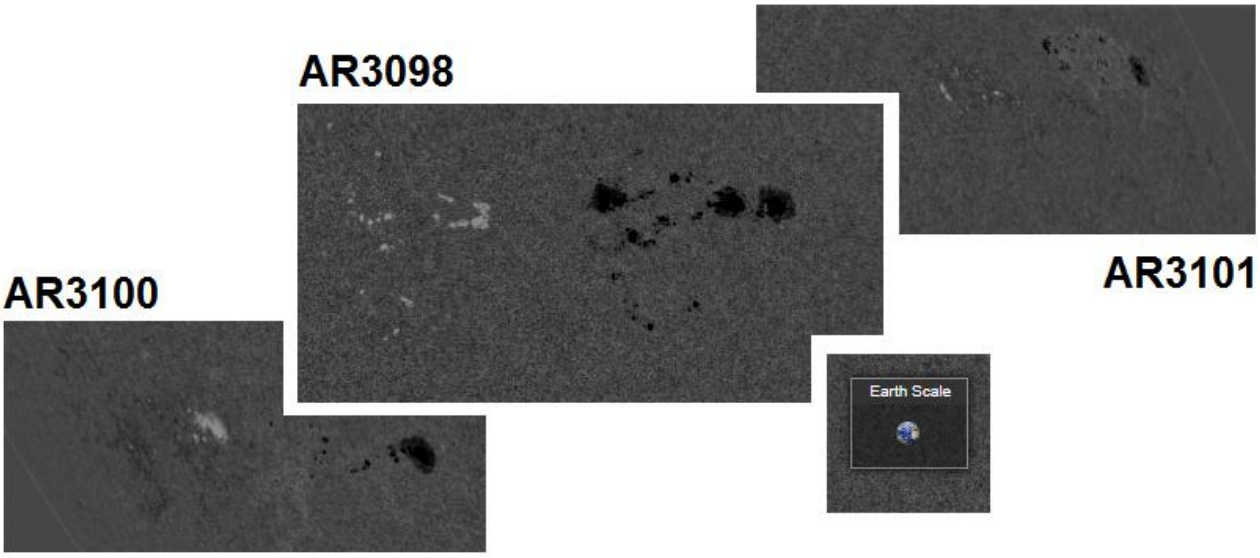
Figure 3: Helioviewer.org-generated HMIIF 24-hour difference imagery 10/2345UTC (white) and 11/2245UTC (black). Note especially the marked areal growth and spot proliferation in AR3098 (centre). Earth shown for scale.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) observed by GOES-16 remains near Background values, but with a very slight enhancement evident that has plateaued near 1pfu.

The source of this slight increase may be tied to one of the rearward-directed limb CMEs of 08 September, with a relatively soft onset and rise seen. Whatever the source, repeats of such activity are not considered likely.

The daily chances of S1 or greater have been revised upwards slightly relative to recent guidance, due to the number and increased complexity of westward-advancing sunspot groups on the disc, although this does not appreciably deviate from 5% over the four days.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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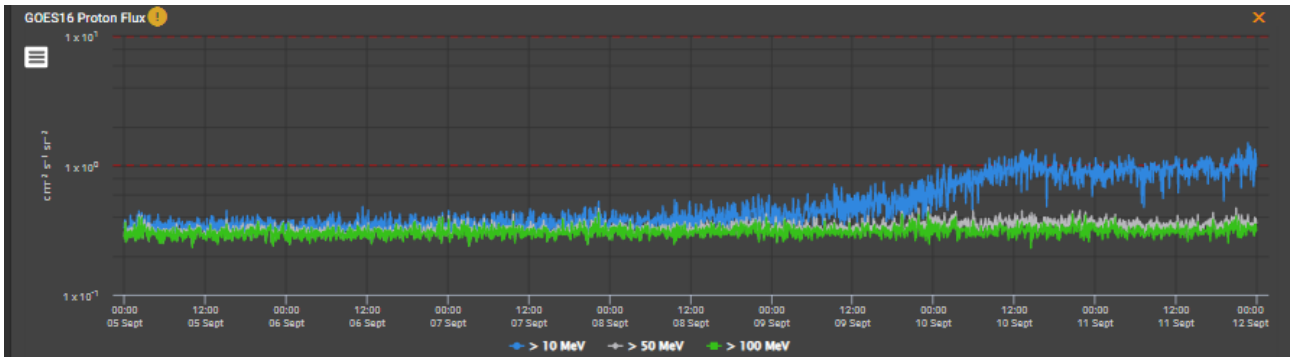
Figure 4: The past week in 10MeV protons (blue), showing a gradual response to a presumed far-side CME to 1pfu. Further such enhancements from a similar source are not expected, although the daily risk of S1 has risen due to front-side developments.



High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electrons have shown a significant response to the long-lasting duo of fast winds from CH20/+ and now CH24/+. Levels are currently fluctuating between High and Moderate, with the diurnal peak seen in the last 24 hours actually rising relative to recent days - presumably in the absence of Active geomagnetism. This is probably representative of the undamped diurnal oscillation and should be the peak for the period, with a gradual ebb of counts probably now commencing as the fast wind further wanes.

The associated 24-hour fluence levels are expected to persist above the Active threshold for much of the period, but with an increasing chance of falling below from midweek UTC with the prospect of a vestigial coronal hole (CH22/-) and perhaps the 09 September CME.

MOSWOC REFM is considered to give reasonable guidance for the overall trend at first, though perhaps a little early in its reduction below Active levels. The presence of at least one transient should render this forecast less reliable around the middle of the coming week.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	70	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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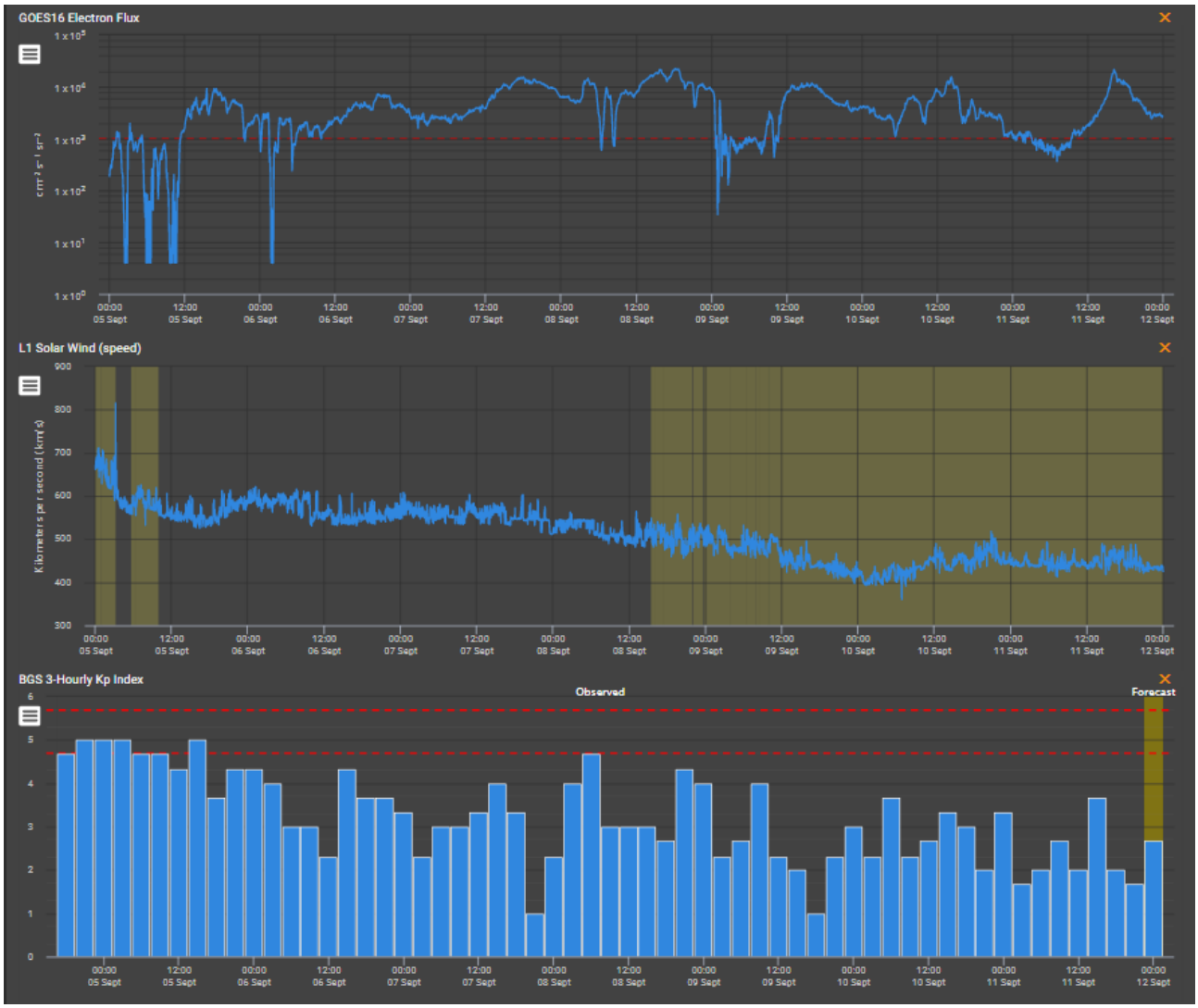
Figure 5: Past week in 2MeV electron flux (top); L1 solar wind speed at DSCOVR and ACE (yellow shading), middle plot; BGS Kp geomagnetic activity. The current oscillation is liely to be the maximum for the period, with a gradual waning now expected, probably accelerating after midweek should any geomagnetic activity result from CH22 and/or the 09 September CME.



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